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Circ. A Summary of Current Program, 7/1/63  
and Preliminary Report of Progress  
for 7/1/62 to 6/30/63

HUMAN NUTRITION RESEARCH DIVISION  
of the  
AGRICULTURAL RESEARCH SERVICE  
UNITED STATES DEPARTMENT OF AGRICULTURE

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This progress report of U.S.D.A. and cooperative research is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on U.S.D.A. and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued between July 1, 1962, and June 30, 1963. Current agricultural research findings are also published in the monthly U.S.D.A. publication, Agricultural Research. This progress report was compiled in the Human Nutrition Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Maryland.

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UNITED STATES DEPARTMENT OF AGRICULTURE  
Washington, D. C.  
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## INTRODUCTION

The research reported here presents recent progress in understanding the nutritional needs of normal man and the manner by which these needs can best be met by food. The research involves studies of the absorption, transport and metabolism of individual nutrients in the body as related to age, activity and environmental conditions. Studies of metabolic processes and nutritional requirements in man are preceded, guided and expedited by results from intensive studies on laboratory animals and lower forms of life in which all factors can be rigidly controlled and physiological responses can be measured during each stage in the life cycle and during successive generations. The research includes the nutritive and other consumer values of foods as measured by chemical or physical means and by biologic response, and the effects of household practices upon the nutritive value and inherent qualities of foods. Applications of the knowledge gained from human nutrition research influences the food habits and nutritional status of man and also market demand and the orientation of agricultural production.

The program is carried on by the Human Nutrition Division of the Agricultural Research Service of the U. S. Department of Agriculture. It is conducted at the Agricultural Research Center near Beltsville, Maryland, and under contract and cooperative agreement with universities, medical schools, hospitals and industry. In addition, the division collaborates with Regional programs of the State Experiment Stations. The federal scientific effort devoted to this research in Fiscal Year 1963 totalled 60.0 professional man-years with 56.8 engaged in the program near Beltsville, Maryland, and the equivalent of 3.2 in contract and cooperative agreements. The program is divided almost equally among study of: The functions and requirements of nutrients; the nutrient composition and value of foods; and other food qualities and consumer use, with respective assignment of about 23.4, 19.0 and 17.6 professional man-years.

Basic information on human nutrition is needed for conservation and optimal utilization of human and food resources in our expanding population. The division has contributed to this goal by providing information on nutritional and food needs and on the qualities of foods which influence their usefulness to consumers. Some of these contributions have been summarized here:

More evidence that diet influences lifespan. Completion of long-term investigations with laboratory animals fed 29 different experimental diets has given us a better understanding of specific relations between diet and health and longevity. Both excessive food intake and relationship or balance of nutrients in the diet are implicated in the adverse

effects that occurred throughout the lifespan of the laboratory animals. The studies also indicate that genetic strain affects the response to the different diets and thus emphasize the importance of recognizing inherited characteristics in evaluating responses to diets. Rats that ate excessive amounts and gained at a rapid rate died at an early age regardless of the composition of the diet. Survival varied even with diets of similar fat and protein content. Differences in serum cholesterol levels of animals showed no relationship to kind or level of fat nor to level of dietary cholesterol.

Vitamin B<sub>6</sub> in cereal products determined by new method. An accurate method was developed for separating and measuring the three chemically related compounds of the nutritionally essential vitamin B<sub>6</sub>--pyridoxine, pyridoxal, and pyridoxamine. This advance will make it possible to secure much needed information on vitamin B<sub>6</sub> components in food. Most whole grains and products from whole grains assayed contained 2 to 4 micrograms of vitamin B<sub>6</sub> per gram, whereas highly processed cereal products such as all-purpose flour, white bread, precooked rice, noodles, macaroni, and spaghetti generally contained less than 1 microgram.

Heat processing of homemade pickles recommended. Recently completed research indicates that pickled fruits and vegetables require heat treatment to insure bacteriological safety. Adequate processing in a boiling water bath destroys the organisms that cause spoilage and inactivates the enzymes that can cause undesirable changes in color, texture, and flavor during storage. The processed pickles not only keep better than nonprocessed pickles but are generally superior in color, texture, and flavor. Instructions for heat processing of homemade pickles have been incorporated in a bulletin that will be available to the large numbers of rural and urban families that preserve food by pickling each year.

Baking temperature to make dried egg products safe from Salmonella. Baked foods containing dried egg can be safe from Salmonella organisms if temperature throughout the product reaches a minimum of 160° F. The point of slowest heating may be slightly above the center for viscous and high protein foods. Division scientists established these findings from measurements of heat penetration during the baking of 24 food products made with dried eggs. Instructions have been developed for safe use of dried egg in the Federal school lunch program and in food distribution programs for institutions, summer camps, and welfare families.

These examples demonstrate how research in the Human Nutrition Division assists and can continue to assist the United States Department of Agriculture in its responsibility for producing enough food and a proper assortment of foods to meet the nutritional needs of the nation's citizens within the general framework of their food habits.



## AREA NO. 1: FUNCTIONS AND METABOLISM OF NUTRIENTS

Problem. To clarify the functions and metabolic pathways of nutrients much of the nutrition research must be done with laboratory animals and lower forms of life. Only with animals of short lifespan and on controlled diets can both immediate and long-term physiological responses be measured by various biochemical, biological, and histological methods during every stage in the life cycle and during successive generations. Studies of the morphological structure, biochemical composition, and physiological function of organisms, isolated cells, and cell fragments are needed to extend understanding of nutritional processes. The kinds and amounts of nutrients and energy essential for growth and maintenance of body tissues and for nutritional well-being are influenced by such factors as climate, physical activity, pregnancy and lactation, as well as by the hormone and enzyme activity that reflects heredity, aging, and sources of stress. Both qualitative and quantitative measures are needed of the extent to which these factors influence nutritional needs, metabolic response to various nutrient combinations, and physiological changes within tissues. Results from investigations with laboratory animals, microorganisms, and cells guide research in human nutrition and help to explain metabolic responses to diet.

### PROGRAM

Current investigations are underway with laboratory animals to determine the effects of nutrients and foods on growth, reproduction, and longevity, on the composition of blood and tissue, and on the structure and functioning of tissues at various stages of the life cycle. Chief variables under study are the kinds and amounts of dietary fats and fatty acids, proteins and amino acids, and carbohydrates. Included also are studies of interrelationships among nutrients when fed in purified form and when supplied from foods. Studies of cellular metabolism are developing new insights into functions, requirements, and quantitative relationships of nutrients important to the nutrition of men.

The program on the functions and metabolism of nutrients is conducted at Beltsville and under contract and cooperative agreement with private laboratories and at universities and medical schools. The studies require staff with specialized training in nutrition, biochemistry, microbiology, histology and pathology.

The Federal scientific effort devoted to research in this area totals 17.8 professional man-years distributed as follows: Lipids, 6.7; proteins, 4.7; carbohydrates, 1.9; minerals, 2.2; vitamins, 2.3.

## PROGRESS

### A. Lipids

1. General. Long-term investigations with laboratory animals fed 29 different experimental diets did not implicate any one food in the adverse effects that occurred when certain dietary combinations were fed. The results also provided further evidence of the role of heredity or excessive rate of gain in body weight as factors influencing biological response to diet.

In one series of experiments the level of dietary fat was 9 to 17 percent and the added fats were dehydrogenated vegetable oil, butter, or lard. In a second series, the level of dietary fat was 17 to 19 percent with egg, milk, beef, or peanut butter supplying a large proportion of the fat. Growth of the young rat was good on all of the diets with no evidence of any dietary deficiency. Survival varied, however, even with diets of similar fat and protein content. Animals weighing 600 grams or more by the time they were 200 days old died at an early age regardless of diet. Survival was longer with a diet consisting of 100 percent whole egg than with one containing 25 percent egg, suggesting that the particular combination of nutrients rather than egg alone was responsible for the differences observed. The influence of heredity was apparent in the difference of 200 days in survival of two strains of rats fed under identical conditions a diet containing 25 percent egg. A bulletin reporting the results of the investigations has been completed.

2. Cholesterol. Investigations are nearing completion on cholesterol levels in serum, adrenals, and liver from animals fed the following dietaries: cholesterol as such or as it occurs in egg, hydrogenated vegetable oil, lard, butter, safflower oil, corn oil, or a blend of fats fed in conjunction with egg. Papers are in preparation reporting the results of these studies.

3. Heredity. A study is nearing completion to characterize the BHE strain of rats used in division studies of biological response to diet, and to determine the extent to which one type of genetic linked characteristic (susceptibility to kidney damage) may influence the response of two lines of inbred rats to different types of diets. The data collected for approximately 3000 rats were coded and submitted for computer analysis. Evaluation of results awaits completion of statistical analyses.

Serum and liver cholesterol measurements will be made on 500 livers to obtain more information on the relation between cholesterol metabolism and heredity.

4. Heated and oxidized fats. Lifetime studies with rats to determine the effect of heat treatment upon the nutritive value of cottonseed oil, lard, corn oil, and a blended mixture containing hydrogenated vegetable fat were continued in contract research at Chicago, Illinois. The first replication of animals has been under study for 84 weeks and the last replication for 66 weeks. Digestibility and food utilization studies were carried out during the 2nd, 12th, and 52nd weeks. Randomly selected animals were sacrificed at 22, 36, and 50 weeks of age and fixed tissues sent to the Beltsville laboratories for histological examination.

Research on the effect of feeding rats, throughout their lifetime, diets containing fresh and oxidized olive and cottonseed oil was continued under contract in New York City. The rats have been under study for 85 weeks and randomly selected animals were sacrificed at 34 and 73 weeks of age. Internal organs and blood serum were analyzed for cholesterol, individual fatty acids, and mineral content; fixed tissues were examined histologically. Structural analyses of triglycerides in the diets and in adipose tissue have shown that rats produced molecular types not present in the dietary fat although the structure of the depot fat was strongly influenced by the dietary fat. Oxidation of the dietary fats exerted only a mild effect on the structure of the depot fat triglycerides. These findings will be presented to the American Oil Chemists Society, September 30-October 2, 1963. Contract arrangements were completed for similar studies on fresh and oxidized butter and lard.

5. Dietary carbohydrates. Investigations to determine the influence of sucrose, glucose, or starch on the lipid metabolism of the rat are nearing completion. Lipid measurements include not only cholesterol but total fat in the liver and carcass and total serum fatty acids. Papers will be prepared reporting the results of these investigations.

Studies on the effect of the kind and amount of dietary fat and carbohydrate on lipid metabolism were continued in contract research at Oakland, California. Low-fat diets and diets containing moderate amounts of either corn oil or hydrogenated coconut oil were fed to 14 additional puppies. Each diet was fed with carbohydrate furnished by (a) corn syrup, (b) sucrose, (c) beta lactose, and (d) dextri-maltose. Samples of blood serum were analyzed for content of different lipid classes, and each lipid class was analyzed for content of individual fatty acids. Skin biopsies were examined histologically.

6. Tissue structure. Recently completed long-term studies with rats have shown that both diet and aging affect the development of kidney and vascular lesions in the rat. The diets investigated contained approximately 25 percent protein and 17 to 19 percent fat. The foods supplying fat and protein were egg, milk, beef, and peanut butter.



Although kidney disease increased with age regardless of diet, the onset and severity of the lesions appeared to be accelerated by certain combinations of dietary ingredients. When kidney damage was severe, degenerative changes were found in the heart and arteries which were probably mediated by parathyroid hyperplasia secondary to kidney disease. These alterations in the cardiovascular system, while differing from atheroma, resembled other types of human vascular disease. A paper reporting these results has been submitted for publication.

Further experiments are in progress to determine to what extent a specific dietary ingredient or combination of ingredients may be associated with the lesions observed.

## B. Proteins

1. Serum proteins. With diets in which the source of carbohydrate was varied, further evidence has been obtained to indicate that diet and age may influence the amount of rapidly moving protein components (PA) in the blood serum of rats. The presence and amount of these components may provide an additional means of measuring response to diet constituents and may prove a valuable tool for studying lipid transport. The state of fast at the time of sacrifice of the animal also was found to be a factor of importance.

PA was present more often and in larger amounts with fasted rats fed a sucrose-containing diet than with rats of comparable age on a starch-containing diet. With either carbohydrate, more PA was generally present in the serum of 350 day-old rats than in that of 150 day-old animals. With glucose, PA was present in small amounts in a larger percentage of rats, and no age effect was apparent. The percentage of 150 day-old sucrose-fed rats with serum containing PA was higher in nonfasted than in fasted rats; the reverse was observed with glucose. Lipid material was found in the PA component. The function of this lipid-bound protein in the metabolism of dietary fats and carbohydrates remains to be elucidated.

2. Body composition. Research on the effect of inhibiting the in vivo breakdown of urea on protein utilization is continuing under contract at Chicago, Illinois. The weight gain and body composition of urease-immunized and nonimmunized rats fed either soybean protein, wheat gluten, or casein are being determined. Results will contribute to understanding of factors influencing protein utilization.

3. Protein synthesis. The amino acid concentration of cell pools from Tetrahymena pyriformis was significantly higher when carbohydrate was supplied as glucose than when present as dextrin. This concentration difference appeared to be independent of osmotic effects in young cultures. The concentration of alanine, glycine and glutamic acid were higher, while those of serine and threonine were lower in cells from glucose media.

At high media concentrations, serine and threonine exhibited reciprocal interactions on growth and on cellular accumulations of amino acids in T. pyriformis. Serine also inhibited arginine, and arginine inhibited threonine, the latter inhibition being reversed by additions of glycine. Arginine utilization was inhibited by high levels of serine. When this occurred the serine level of the cell pool was approximately five times as high as in a parallel pool from uninhibited cells. Smaller differences were apparent in the relative concentration of threonine and of glutamic and aspartic acids. Greater detail is being obtained on amino acid composition of cell pools.

4. Serine synthesis. L-alanine and L-threonine effectively inhibited growth of Leuconostoc mesenteroides in serine-free media containing p-aminobenzoic acid, or one of several reduced derivatives of folic acid. A three-fold molar excess of L-alanine with respect to glycine and a five-fold molar excess of L-threonine reduced growth by one half.

Results from further studies suggest that the inhibition of serine synthesis by alanine and threonine is effected through (1) preventing accumulation of effective concentrations of glycine in cellular amino acid pools, and (2) inhibition of the enzymatic (serine hydroxymethylase) conversion of glycine to serine. A manuscript to report these findings has been submitted to the Journal of Bacteriology.

Four major components active in the conversion of glycine to serine by L. mesenteroides have been isolated from cell extracts. These reduced, conjugated derivatives of folic acid appear as the synthesis of serine proceeds.

#### C. Minerals

Calcium, phosphorous, and magnesium. Studies of the effect of kind and amount of dietary fat upon calcium, phosphorous, and magnesium in kidneys and serum of rats have been extended to include the measurement of these minerals in the eviscerated rat carcass and in urine.

#### D. Vitamins

1. Thiamine. Investigations have been initiated to determine the influence of varying dietary levels of thiamine prior to and during pregnancy on reproductive performance and on the metabolic response to diet of the pregnant animal. Data will be obtained on maternal weight gain, size of litter, litter weight, incidence of resorptions, maternal hemoglobin, hematocrit, total serum protein, and serum protein fractions. Selected maternal tissues and fetuses will be analyzed for thiamine as a means of determining the state of nutrition with respect to thiamine.

2. Quinones and electron transport. Further investigations of the vitamin K<sub>2</sub>-like naphthoquinone of Bacillus stearothermophilus have shown

that it is largely (85%) associated with the cell membrane fraction of osmotically disrupted cells. The oxidative and phosphorylative ability of this fraction was retained only at the substrate level; i.e., pyruvate oxidation was lost and only NAD-linked, or succinate-linked oxidative systems, exhibiting partial phosphate esterification prevailed. In contrast, sphaeroplasts of the thermophile retained complete citric cycle capability including pyruvate oxidation, their oxidation and phosphorylation rate slightly exceeding that of whole cells on an equal numbers basis.

Much of the activity of both the membrane and the soluble fractions was lost by exposure to light at 360 mu, but when these light-inactivated fractions were incubated together at 60° C. an eventual phosphorylative level was reached comparable to the rate in non-treated material. Thus, the membrane fraction together with soluble components appeared capable of synthesizing or reactivating a naphthoquinone intermediate. The original phosphorylative rate was achieved rather suddenly within a five to ten minute interval of a 40-minute incubation period.

## PUBLICATIONS

### Lipids

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O'Barr, T. P. 1962. Serine synthesis by Leuconostoc mesenteroides. Proc. Soc. Expt. Biol. Med. 110, pp. 867-69.

Lakshmanan, F. L. 1963. Factors influencing the presence of rapidly migrating serum protein component(s), PA. Federation Proc. 22(2), Part 1, p. 608 (abstract).

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Reynolds, H. 1963. Potential analytical applications of Tetrahymena pyriformis. Paper presented to a Panel on Vitamin and Amino Acids, Analytical Microbiology Group, 63rd Annual Meeting, American Society for Microbiology, Cleveland, Ohio, May 8, 1963.

### Vitamins

Brown, M. L. 1963. Effect of a low dietary level of three types of fat on reproductive performance and tissue lipid content of the vitamin B<sub>6</sub>-deficient female rat. Jour. of Nutr. 79, pp. 124-130.



## AREA NO. 2: HUMAN METABOLISM AND REQUIREMENTS FOR NUTRIENTS

Problem. Research in human metabolism is conducted to determine the kinds and quantities of foods and nutrients needed by individuals for nutritional well-being, and the factors that influence nutritional needs. Systematic biochemical and physical observations of persons on self-chosen and controlled diets provide information on the use of nutrients in the body in relation to age, activity and environmental conditions; and on the quantities of nutrients and food energy required by persons of different ages, by those accustomed to different food patterns, or living under different environmental and nutritional conditions. The absorption, transport and metabolism of individual nutrients and groups of nutrients are investigated. Results of this research aid not only in defining average human requirements for nutrients and for food but also in establishing the lower and upper limits of nutrients and of food combinations conducive to human well-being. Studies are also made of the nutritional status of individuals. Such information is essential for the optimal utilization of our food resources and to all programs for improving nutrition. Application of such knowledge will influence food habits, nutritional status, market demand and the orientation of agricultural production.

### PROGRAM

USDA research on human metabolism places major emphasis on determining the quantities of nutrients required by persons of different ages on self-chosen and on controlled diets, and on measuring the metabolic behavior of individuals with regard to several nutrients at the same time. The current program deals particularly with factors affecting the metabolism of fat and protein and with mineral and vitamin requirements. Other studies seek to establish the range in biochemical response among individuals on controlled and self-chosen diets. Measurements are made on intake, outgo, levels in the blood and other criteria available in the living organism. Systematic compilation and reevaluation of all available knowledge on subjects of special nutritional significance are made to indicate gaps which should be filled by research, to prevent unnecessary replication of work, and to suggest the most promising areas for new research.

The program is carried out in the laboratories at the Agricultural Research Center through contract and cooperative agreements with universities and medical schools, and through participation in Regional Projects of the State Agricultural Experiment Stations. Nutritionists, biochemists, physiologists, physicians and statisticians cooperate in the program.

The Federal scientific effort devoted to research in this area totals 5.6. Of this number 2.8 are devoted to metabolic behavior and 2.8 to nutrition requirements.



## PROGRESS

### A. Metabolism

1. Lipids. The applicability of a uniform diet to the study of metabolic response in humans was investigated using commercially prepared liquid diets to provide all nutrients in the same proportion at each meal. Lipid metabolism was studied for 15 women 22-64 years of age maintained for 60 days on the uniform diet. Two kinds of diets differing mainly in energy value derived from fat and carbohydrate were investigated. The regimen for investigation of metabolic response was as follows: for four women the daily diet provided 900 Calories, for three women, 1600 Calories, and for the other eight women the two diets were fed alternately with 20-day periods on each diet. Each diet provided about 12 gm. of nitrogen daily. Mean blood serum levels of cholesterol, phospholipids, and triglycerides fell after 19 days on either diet. When the diets were alternated, the mean blood lipid levels appeared to shift in the same direction as the caloric intake and in the opposite direction to that of the saturated fatty acid ratio in the diet.

For the most part, the mean nitrogen balances were positive and did not differ significantly for the two diets. Calcium balances were predominately positive on intakes of about 2 gm. daily with negative balances occurring only on the 1600 Calorie diet. Loss in body weight for the 15 women over the 60-day period ranged from 3 to 27 pounds.

Manuscripts are being prepared for publication presenting results obtained in contract research at Los Angeles, California, on the effect of the type of dietary protein on the response to variations in dietary linoleic acid and at Lincoln, Nebraska, and Battle Ground, Indiana, on the effect of the amount of dietary protein on the response to a constant amount of dietary linoleic acid.

2. Minerals. Data on calcium, magnesium, and phosphorus balances for twenty-five young men were obtained from materials resulting from contract research at University, Alabama; Fayetteville, Arkansas; and Pullman, Washington, in which the dietary variable was the linoleic acid content of the fat.

At one contract location (Alabama), the analytical work has been extended to include balance data for three additional minerals; sulfur, sodium, and potassium. The results obtained on the effect of increasing the linoleic acid content of the dietary fat from 10 to 26 percent on serum lipid levels, on the metabolism and retention of nitrogen and six minerals, and on the excretion of fat for seven young men will be summarized for publication as a research bulletin at the University of Alabama.

3. Metabolic behavior. Previous division research on the effect of diet on human fat metabolism placed major emphasis on the fatty acid content of the dietary fat and on the kind of dietary carbohydrate.

A current project at Beltsville deals with another phase of the problem; namely, the effect of rate of food intake on the metabolic behavior of normal individuals. A study on the effect of frequency and size of meals is in progress with fifteen healthy young women serving as subjects. The effect will be measured by nitrogen and mineral balances; by the amount of fecal lipids excreted; by levels of selected vitamins in blood serum and urine; and by blood serum levels of lipid components and minerals.

## B. Requirements for Nutrients

1. Adolescent age group. Data on the metabolic patterns of normal adolescent and preschool age boys and girls are needed for more definitive understanding of their nutrition needs. Work has been initiated and will continue on a multiple-nutrient basis for these age groups. Data accumulated will make it possible to establish ranges in metabolic response for young persons of different ages when undergoing periods of rapid or diminishing growth rates.

A study of nutritional needs of adolescents was conducted under contract at Berrien Springs, Michigan, with a group of adolescent girls, 16 to 19 years of age. The controlled diet used was designed to measure the metabolic response to an ovo-vegetarian type of diet. The major portion of the dietary fat was provided by butter and corn oil. The study will provide data on intake and outgo of nitrogen, fat, and selected minerals, and on blood lipid patterns for use in assessing nutritional requirements of adolescent girls. To obtain data for a more representative group of girls on an ovo-vegetarian type of diet, a replicate study is being planned with another group of 16 to 19 year old girls. Long range plans include studies with younger adolescents using controlled diets with different combinations of food and different levels of nutrients.

2. Preadolescent age group. Cooperation has continued with experiment stations in the Southern Region (S-28 revised) for investigation of metabolic patterns and for assessing requirements for and utilization of selected nutrients by preadolescent children. In 1962 at Blackburg, Virginia, 12 preadolescent girls were maintained on controlled diets with variation in the amount of protein (entirely from plant sources) and in the amount of riboflavin. Analyses completed for intake and outgo of fat suggest that the amount of fecal fat excreted by the subjects was about twice the amount of fat excreted by subjects on controlled diets in earlier studies, where the protein was mainly from animal sources, although the content of total fat in the diets was comparable.

The Division's share of the cooperative work also completed are analyses (1) for content of total cholesterol, phospholipids, and triglycerides in blood sera determined for each girl at the beginning and at the close of the controlled feeding phase of the study and (2) for intake and urinary outgo of vitamin B<sub>12</sub>.

Recognizing the importance of summarizing all data for four cooperative metabolic studies carried out under cooperative Southern Regional Project S-28, the detailed data listings for balance studies for 35 preadolescent girls involving over 30 individual constituents in food, urine, and feces are being prepared for publication as a research bulletin. This publication will bring together detailed metabolic data for an age group for which only limited data have been available for use in developing recommendations for nutrient intake.

3. Young adults: Amino acid patterns in food proteins. Combined nitrogen-balance data for 35 adults are being analyzed statistically to determine the influence of several factors upon nitrogen balances on diets containing the FAO pattern of essential amino acids and the patterns in nonfat milk solids, whole egg, oatmeal, peanut butter, and wheat flour. The studies were made under contract at four locations (Alabama, California, Oklahoma, and Wisconsin).

#### C. Physical Measurements

Height-weight relationships are important as one physical criterion for assessing nutrition of man.

A study of height-weight data from about 160,000 college students indicated that for men weight was relatively stable between ages 21 and 29 years and for women between ages 17 and 29 years. Therefore, these ages were used to establish the average height-weight relationship for adults. The relative rate of increase in weight (in kilograms) is about one percent per centimeter height for both men and women although for any given height, the weight of women is about 9 percent less than that for men. These data, useful in classifying subjects for nutritional studies, have been summarized and a manuscript accepted for publication in the American Journal of Clinical Nutrition.

PUBLICATIONS

Metabolism

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Kirk, M. C., Metheny, N., and Reynolds, M. S. 1962. Nitrogen balances of young women fed amino acids in the FAO reference pattern, the milk pattern, and the peanut pattern. Jour. Nutr., 77, (4), pp. 448-454.

Leverton, R. M. and Steel, D. 1962. Nitrogen balances of young women fed the FAO reference pattern of amino acids and the oat pattern. Jour. Nutr., 78 (1), pp. 10-14.

Swendseid, M. E., Harris, C. L., and Tuttle, S. G. 1962. An evaluation of the FAO amino acid reference pattern in human nutrition. 2. Studies with young women. Jour. Nutr., 77, (4), pp. 391-396.

Moyer, E. Z., Goldsmith, G. A., Miller, O. N., and Miller, J. 1963. Metabolic patterns in preadolescent children. VII. Intake of niacin and tryptophan and excretion of niacin or tryptophan metabolites. Jour. Nutr., 79, (4), pp. 423-430.



### AREA NO. 3: NUTRIENT VALUES OF FOODS

Problem. The nutritional value of foods to man represents the combined effects of the proportion and form of nutrients as found in single foods or as combined with others in the ordinary diet. Knowledge of these food components is essential for estimating the dietary contribution of individual foods and the nutritional adequacy of diets of population groups. Analyses of foods by chemical and physical means indicate potential nutritive value and are the basis of food composition tables used by nutritionists and clinicians. Continuing analysis of market-available foods is necessary to keep data on nutrient content current with the adoption of new varieties, and production, processing and marketing practices. Data on both cooked and raw foods are needed to determine the effects of household and institution preparation methods upon the nutrients in foods and to derive realistic figures for nutritive value of diets. Reliable methods and assay techniques must be evolved for estimating the physiological utilization of the nutrients.

#### PROGRAM

Foods, representative of various production sites and practices, processing and marketing procedures, are analyzed as purchased from the market and as prepared for eating by the consumer. Analyses are made for many nutrient components including amino acids, fatty acids, minerals and vitamins. Values for calorie, protein and fat content are derived from analyses made of the proximate composition. Methods are developed for newly identified nutrients and forms of nutrients; existing methods for known nutrients are improved and adapted for use with different foods.

New approaches to the evaluation of the nutritional value of foods are being explored through measurement of the response of microorganisms and small animals to the various components of food fed as the whole food and when substituted singly in a diet medium calculated to simulate the whole food. Methods are being modified to undertake studies with humans.

The research is conducted at Beltsville, Maryland, and under contract and cooperative agreement in the laboratories of universities, medical schools and industry. Chemists, biochemists, biologists, and statisticians participate in the program.

The Federal scientific effort devoted to research in this area totals 19.0 professional man-years. Of this number 4.3 are devoted to vitamins; 2.1 to mineral elements; 5.7 to fatty acids; 2.1 to protein and amino acids; 2.7 to proximate composition; 2.1 to carbohydrates.

## PROGRESS

### A. Vitamins

1. Grain and grain products. The distribution of three vitamin B<sub>6</sub> components in selected cereal foods was determined by chromatographic separation of pyridoxine, pyridoxal, and pyridoxamine--and yeast assay of the eluted fractions. Grains and cereal products showed differences between total vitamin B<sub>6</sub> in the unchromatographed extract and the total of pyridoxine, pyridoxal, and pyridoxamine of the chromatographed extract. The latter procedure was considered more reliable.

Among the 56 grains and cereal products analyzed for vitamin B<sub>6</sub> were: whole grains; barley, corn, popcorn, rice, rye, and wheat; cornmeal and 5 kinds of flour; 6 breads; 7 cereals to-be-cooked; 9 ready-to-eat cereals; 5 precooked infants' cereals; and egg noodles, macaroni, spaghetti, and wheat germ. The grain products generally contained large proportions of vitamin B<sub>6</sub> as pyridoxine or pyridoxal. Wheat and rice had over 70 percent pyridoxine and corn over 50 percent pyridoxal. Only barley and corn appeared to contain as much as 30 percent pyridoxamine. Most whole grains and cereal products made of whole grains contained 2 to 4 micrograms of vitamin B<sub>6</sub> per gram, while other cereal products such as all-purpose flour, white bread, precooked rice, noodles, macaroni, and spaghetti generally contained less than 1 microgram per gram. Part of the loss in processing may be attributed to refining as shown by the relatively large amount of vitamin B<sub>6</sub> in wheat bran (8 micrograms per gram) as compared to all-purpose flour (0.58 micrograms per gram). The studies are being summarized for publication.

The nitrogen content of whole grains and cereal products simultaneously analyzed for vitamin B<sub>6</sub> showed no relationship to the content of vitamin B<sub>6</sub> in these products. Products which had been refined (e.g., removing bran from whole wheat) had much lower vitamin B<sub>6</sub> to nitrogen ratios than did whole grains, indicating much greater losses of the vitamin than of nitrogen. For instance, as an extreme example, the nitrogen content of bran was 1.86 percent, that of all-purpose flour, 1.85 percent, although vitamin B<sub>6</sub> content of the bran was some 15 times greater than that of flour.

Study of the effect of cooking times and temperatures on vitamin B<sub>6</sub> content of foods has been initiated. A number of available fruits and vegetables will be analyzed for their content of the different forms of vitamin B<sub>6</sub>.

2. Meat and meat products. Analyses for niacin, riboflavin and thiamine have been completed on samples of separable lean from 24 paired fresh and cured hams. The results will be prepared for publication. These data were obtained through contract research at the University of Illinois.

3. Improved analytical procedures. Research continued on procedures useful for B-vitamin analyses to permit characterization of B-vitamins in foods and their overall distribution in the food supply. A procedure has been developed for the quantitative determination of pyridoxine (vitamin B<sub>6</sub>) as pyridoxal cyanohydrin. Studies will be continued to apply this chemical procedure to the assay of vitamin B<sub>6</sub> in food extracts and to verify results by comparisons with those of the microbiological assay.

An improved method for thiamine determination has been developed. The conditions of the 6-aminothymol colorimetric reaction were changed so that a stable fluorescent compound was produced with thiamine. The fluorescence made possible measurements at much lower concentrations and appeared to be simpler than the usual thiochrome reaction.

## B. Mineral Elements

1. Fruits. Laboratory analyses for the content and distribution of 10 mineral elements in 29 fresh fruits and 6 dried fruits from different locations are near completion. The mineral element content of several fruits varied from location to location. Data are being summarized for statistical analyses and a technical bulletin will be prepared.

2. Meat and meat products. The content of mineral elements was determined in composite samples of separable lean, cover fat, intermuscular fat, and waste from paired hams, cured and cooked cured, including drippings from the cooked hams. The data are being summarized and a manuscript will be prepared on the effect of roasting or baking upon the mineral element composition of cured hams. The hams were obtained as part of a research contract with the University of Illinois.

3. Diet composites. Mineral analyses were made on 16 composites of foods chosen to represent nutritionally adequate diets for boys 16 to 19 years of age. The samples were received from the Nutrition Division of the Food and Drug Administration as part of a cooperative study with the National Institutes of Health and the Atomic Energy Commission to determine the effects of fallout on foods. The composites of foods were obtained from four different marketing channels in the Washington, D. C. area at four times or seasons during 1962. An additional four samples were obtained--two from Washington, D. C., and one each from the midwest and the far west.

Mineral composition of these composites did not differ greatly from market to market, or with location or time of purchase. Calcium and phosphorus content and Ca/P ratios approximated dietary recommendations. Copper, iron, sodium, potassium, and magnesium were found to be more than adequate. The data confirm the nutritional adequacy of the kinds and amounts of food planned for boys of this age group.



### C. Proximate Composition

Determination of the proximate composition of foods; i.e., moisture, fat, Kjeldahl nitrogen and ash, was carried out in conjunction with studies for other nutrients in foods such as the vitamins, mineral elements, fatty acids and carbohydrates.

1. Fruits. Analyses for total nitrogen and ash are in process on the 29 fresh and 6 dried fruits being analyzed simultaneously for mineral element content.

2. Meat and meat products. Proximate composition data have been obtained on the separated portions (lean, subcutaneous fat, intermuscular fat, waste, and drippings) of 48 cured and cooked cured hams representing different degrees of fatness. Similar measurements on cured and uncured hams from comparable carcasses were obtained under contract at the University of Illinois. The data have been prepared for statistical analyses and a technical bulletin will be prepared.

3. Main dish meals. The proximate composition of 38 main dish foods in several market forms--home-prepared, packaged combination, canned, frozen, and chilled--has been determined. These studies were carried out cooperatively with the Fish and Wildlife Service, U. S. Department of the Interior. Plain meats, frozen dinners, sandwiches, pies, fried breaded foods and combination dishes were included in this study. Moisture content of the ready-to-eat foods was influential in determining levels of other nutrients and of energy values. Carbohydrate content tended to vary more with changing moisture content than did fat or protein. Caloric values calculated for sandwiches, pies, and fried breaded foods were high. Combination dishes such as chow mein without noodles were low. For most foods, caloric values tended to follow fat content. Protein content ranged from 5 percent or less in spaghetti and commercial chow meins to more than 15 percent in most plain meats and fried breaded foods. Excluding plain meats and fish, which contained essentially no carbohydrate and for which protein furnished more than two-thirds of the calculated caloric value, the proportions of total energy value derived from fat, protein, and carbohydrate were nearly equal in the main dish foods studied. For all nutrients studied except carbohydrate, canned products differed more from their home-prepared counterparts than did frozen or chilled commercial forms. Commercially prepared foods generally had lower fat, protein, and caloric values, and higher ash and carbohydrate contents than did corresponding home-prepared foods. Composition values for most forms of foods were remarkably consistent among the lots analyzed. The results have been summarized and a technical bulletin prepared for publication.



#### D. Lipids

The fatty acid composition of selected food fats has been determined using gas-liquid chromatography for separation of fatty acid esters. A manuscript was prepared presenting procedures of extraction resulting in minimal alteration in fatty acid composition.

1. Oilseeds and peanuts. Linoleic acid (18:2) comprised over 75 percent of the total fatty acids in safflower oil, 60 in cottonseed, 55 to 60 in corn and in soybean, 30 in peanut and 8 percent in olive oil. Linolenic acid (18:3) made up about 6 percent of the total fatty acids in soybean oil, 1.4 in corn and in olive oils, and about 1 percent in safflower and in peanut oils. Cottonseed oil contained little linolenic acid.

Linoleic acid was found to be some 26 percent of the total fatty acids in hydrogenated vegetable shortening currently available in retail markets, and 7.5 percent in mixed animal and vegetable shortening. Linolenic acid was almost 2 percent in hydrogenated vegetable shortening and 0.5 in the mixed animal and vegetable shortening.

2. Meat and meat products. Linoleic acid (18:2) was found to be 8 to 9 percent of the total fatty acids in lards, and 6.8 percent in mixed pork and beef shortening. Linolenic acid (18:3) was 0.6 to 1.2 percent in lards and 1.0 percent in mixed pork and beef shortening. A sample of ham covering fat contained about 8 percent of the total fatty acids as linoleic acid, and 0.9 percent linolenic acid.

Fatty acids in the studies reported ranged from 8 to 20 carbon atoms in the molecule. The results of the study have been summarized and a manuscript has been prepared for publication in a technical journal. The studies on the fatty acid composition of food fats will be continued and will include studies on vegetables and meats.

Research to determine the changes in fatty acid composition of fat in ground meat produced by cooking has been initiated under contract at the University of Tennessee.

3. Dairy products. The nutritional value of various components of milk are being investigated with rats by feeding diets containing milk protein and all possible combinations of fat as butter oil or corn oil and carbohydrate as lactose or cornstarch. Other rats are being fed dried skim milk and butter oil. At 400 days of age, the effects on body composition and structure will be determined by necropsy, assessment of aorta damage, proximate analyses on carcass and liver and analysis of liver and serum for content of cholesterol and other lipids.

4. Cholesterol. Lipid biosynthesis is being studied as a possible criterion for assessing the nutritional value of foods. Rats developed

acute deficiency symptoms when fed a cholesterol-free diet plus an inhibitor of cholesterol biosynthesis. The content of total sterols in their carcasses and tissues was about the same as for control animals fed a cholesterol-free diet. Analysis of the major sterols by Entomology Research Division showed 75 percent of the total sterols to be desmosterol and less than 20 percent to be cholesterol in the carcasses of the inhibitor-fed rats; in the carcasses of control rats 95 percent of the total sterols was found to be cholesterol. A manuscript presenting these findings has been accepted for publication. In other phases of this research, lipid biosynthesis in relation to age and diet is being investigated.

#### E. Proteins and Amino Acids

1. General. A manuscript was published describing a method developed for assay of alanine using Leuconostoc citrovorum 8081 and including results of analysis of 48 proteins and foods.

Investigation of factors other than amino acids in food hydrolysates which affect the growth response of Leuconostoc mesenteroides P-60 was continued. Manuscripts presenting the results obtained are in preparation. Also studied was the effect of the type of carbohydrate in the basal medium on the essentiality of amino acids for growth of this organism.

2. Grains and vegetables. Protein-rich mixtures of foods from vegetable sources are being developed and their nutritive values determined in contract research using Public Law 480 funds at Jerusalem, Israel. Wheat flour, bulgur, soybean flour, chick peas, sesame flour, and sunflowerseed meal were analyzed for content of total nitrogen and of the three amino acids (lysine, methionine, and tryptophan) which limit the nutritive value of most plant proteins. The values obtained were used as a basis for preparing eight mixtures expected to have relatively high biological values. The nutritive value of the eight mixtures, each prepared to contain 25 percent protein, was assessed on rats by determining protein efficiency ratio, digestibility and biological value, and net protein ratio.

#### F. Carbohydrates

Studies were initiated on direct laboratory analyses for the carbohydrate content of foods, usually expressed as a difference value in tabulations of proximate composition. The sugars in 20 fresh fruits, including deciduous, citrus and subtropical fruits, and berries, were determined by analyses for total sugars, reducing sugars, sucrose (by difference), and glucose and fructose in the reducing sugars by differential oxidation. The studies are continuing on identification and determination of individual sugars in fruits and vegetables.

## PUBLICATIONS

### Vitamins

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- Polansky, M. M. and Toepfer, E. W. 1962. Values for vitamin B<sub>6</sub> components in grains and cereal products. Paper given at meeting of the Association of Official Agricultural Chemists, Washington, D. C.
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- Zook, E. G. 1963. Results of pantothenic acid analyses of diets and feeds acknowledged in "Pantothenic Acid Requirements of Swine for Reproduction," R. J. Davey and J. W. Stevenson, Animal Sci. 22, pp. 9-13.

### Mineral Elements

- Hopkins, H. T. and Murphy, E. W. 1962. Mineral elements in adipose tissue of lamb and pork. J. Agri. Food Chem. 10, pp. 515-517.

### Proximate Composition

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### Protein and Amino Acids

- Warren, H. W., Horn, M. J. and Blum, A. E. 1963. Microbiological determination of alanine in proteins and foods. Analytical Biochem. 5(1), pp. 70-77.

#### AREA NO. 4: FOOD PROPERTIES RELATED TO QUALITY AND CONSUMER USE

Problem. Food properties are altered by heating, chilling, freezing, aeration, physical manipulation, storage, and other practices which comprise household processes of food handling. The quality characteristics of fruits, vegetables, meats, poultry, dairy products, eggs, fats, flour, and cereals depend upon the chemical composition, physical structure, and biological systems characterizing the raw food and the changes induced by preparation procedures. Relationships should be established between the composition and structure of raw and cooked food and those qualities important to the consumer, including ease of handling, perishability, economy of yield, physical appearance, palatability and nutritive value. Such data are fundamental to developing household and institutional methods of food processing and preparation which permit optimal use of available food supplies and consumption of food for good nutrition.

#### PROGRAM

Knowledge of the inherent chemical composition, physical properties and biological systems in raw and processed foods are obtained to provide basic criteria for determination of those characteristics responsible for palatability and functional behavior during consumer use. Principles are established and improved procedures developed for household food preparation, care, and preservation. The research is carried out along commodity lines such as fruits, vegetables, grain and dairy products, meat, poultry and eggs. Specialized studies are also made with selected food items for use in the school lunch and other food distribution programs of the Department.

The work is conducted at Beltsville, Maryland, and through contract and cooperative agreement with university laboratories. Food specialists, chemists, histologists, and statisticians cooperate in this program. The Federal scientific effort devoted to research in this area totaled 17.6 professional man-years last year allocated as follows: 4.0 to fruits; 1.8 to vegetables; 0.9 to grain products; 0.7 to oilseeds and peanuts; 0.3 to dairy products; 4.6 to meat and meat products; 3.0 to poultry products; and 2.0 to school lunch research.

#### PROGRESS

##### A. Fruits

1. Organic acids, carbohydrates, and fruit quality. Research is in progress on the types, amounts, and stability of organic acids and various forms of carbohydrate in fruits before and after freezing. The extent to which these components determine quality, texture, and flavor characteristics



of peaches, strawberries, raspberries, and cantaloups is being studied. Physical and chemical determinations include citric, malic and quinic acids, pectins, soluble solids, titratable acidity, pH, sugars (glucose, fructose and sucrose), reflected color and shear force.

The enzymatic preparation, Pectinol 100-D (Rohm and Haas), in the colorimetric carbazole reaction was found to interfere in the determination of pectins. Pectinol 100-D used in the amounts recommended for the determination of protopectin produced an interfering color which caused a 20 percent error in results in fresh peaches. If Pectinol 100-D is used for pectin determination it is recommended that a correction for the interfering color be made. Pectinol R-10 (Rohm and Haas) and Pectinol (K & K Laboratories) produced no interfering color.

2. Preservation. Formulas for pickled peaches and pears were developed and the effects on quality of processing and storage were investigated. Processed pickled fruits maintained their quality better during storage than did the unprocessed products. The processed pickled fruits showed little deterioration in quality after storage periods up to 9 months. Criteria used were acid, salt, and pH determinations, color difference meter and shear force readings, and panel evaluations of color, texture, and flavor.

3. Storage of dried fruits. Laboratory studies were completed to relate moisture content and quality of uncooked dried fruits of specified types, grades and sizes, that were stored under different conditions, to the quality and yield of the cooked products. A report presenting the results is being written.

## B. Vegetables

1. Preservation. Processing requirements for pickles and relishes made under home conditions were established, based on heat penetration measurements, microbiological examination, and taste panel evaluations. Physical and chemical changes during fermentation, processing, and storage were studied in relation to pickle quality.

Pickled vegetables, like other home-canned food, required heat treatment to destroy organisms that cause spoilage and to inactivate enzymes that may cause undesirable changes in texture, flavor, and color during storage. Adequate heating was best achieved by processing the filled jars in a boiling-water bath. When pickles were processed by the procedures recommended, the lethality values obtained in all cases were in excess of 36 minutes at 160°F., the amount considered necessary for bacteriological safety of the products.

All the pickled products in this study had pH values below 4.6, the pH considered critical in preventing growth of Clostridium botulinum and the production of toxin. Acid values changed very little as the result of processing or storing the pickles.

The salt content of the pickled products was about the same as that of the brine (3 to 5 percent). Only slight changes in salt content resulted from processing or storing.

Soluble solids content of fermented dill pickles ranged from 6.3 to 8.5 percent. Values decreased slightly with storage for fermented and fresh pack dills and dilled green beans. Crosscut pickle slices and sweet gherkins had soluble solids values from 30 to 45 percent. The values were not greatly influenced by processing or storage time.

Processed pickles were generally superior in flavor to unprocessed pickles after storage for periods up to six months. Retention of color and texture during storage of fermented dilled cucumbers was better for processed than for unprocessed pickles, but color and texture of the other pickled vegetables did not appear to be greatly influenced by processing.

2. Use of agricultural chemicals. Quality evaluations were made of sweetpotatoes grown by the Crops Research Division in untreated soil and in soil treated with the herbicide CIPC (isopropyl N-(3-chlorophenyl) carbamate), at the rates of 3 and 6 pounds per acre. The results indicate that CIPC soil treatments did not affect flavor and texture, but slightly changed the color of tubers grown in the treated soil.

Although no statistically significant differences were found by the judging panel between color of the sweetpotatoes grown in untreated soil and those grown in CIPC-treated soil, several significant differences were found when measurements were made by the color difference meter. (1) The untreated sweetpotatoes were more grey in color than those grown in either 3 or 6 pounds per acre CIPC-treated soil; (2) the sweetpotatoes grown in 6 pounds per acre CIPC-treated soil were significantly less red in color than the sweetpotatoes grown in untreated soil. Those grown in 3 pounds per acre CIPC-treated soil were also less red in color than the tubers grown in untreated soil, but the difference was not significant. There were twice as many panel comments of greenish-yellow color in each of the treated samples as in the untreated but the differences in panel mean scores were not statistically significant.

## C. Grain Products

1. Flour measurements. A study was made of the weight-volume relationship of sifted and unsifted flour and its significance in regard to quality of home-prepared baked products. Recent changes and variance in recommendations made by industry regarding methods of measuring flour for household uses made it necessary to obtain information on flour from a number of sources in order to make sound recommendations to consumers. Both all-purpose and cake flour, varied less among replicates when the flour was sifted before measuring than when it was measured without sifting. Unsifted flour spooned directly from the flour container varied less in weight per cup than unsifted flour dipped with a cup from the flour container. Unsifted, spooned flour could be adjusted to the approximate weight of a cup of sifted flour by removing two level tablespoons of flour after measuring. No difference was noted in the quality of baked cakes and muffins made with sifted and unsifted flour when the volume of unsifted flour was adjusted in this manner. When unsifted flour was used without adjustment in volume, muffins and cakes were less acceptable than products made with sifted flour. This information has been published.

2. Pastry mixing methods. Two methods of mixing pastry dough which make high quality pastry with less than the usual amount of fat were developed. One of the mixing methods uses liquid cooking oil, the other uses solid fat. In the oil method water and oil together, both at room temperature, are sprinkled into the dry ingredients while blending with an electric mixer at lowest speed, for 3 minutes. The even distribution obtained by sprinkling the oil and water into the dry ingredients results in a tender, flaky pastry. Corn, cottonseed, soybean, and safflower oil work equally well.

Even distribution of fat and water also is responsible for the success of the solid fat method which allows the use of less fat than usual. Room temperature fat is blended into the dry ingredients with an electric mixer at lowest speed for 2 minutes, then water is sprinkled in and blended 1 minute.

How-to-do-it instructions were released to the general public.

3. Qualities of foreign and domestic rices. A report was completed for publication as a technical bulletin on the quality evaluation of foreign and domestic rices, which summarized the research on rice by four Divisions in ARS (HN, SU, WU, and CR). Quality characteristics of both raw and cooked rice from 33 countries and the United States are reported.

Color of raw rice was associated with completeness of milling; differences in lightness and yellowness were also noted. The parboiled rices were generally darker and more yellow than the regular milled samples; samples from India were the darkest.

The starch granules in short-grain rices generally had lower gelatinization temperatures and were altered more by heat than starch granules in medium- and long-grain varieties. All samples tested from Australia, Chile, Egypt, France, Greece, Italy, Korea, Portugal, Spain, and Turkey, and most of those from Japan had high heat alteration values; those from Colombia, Ecuador, Mexico, West Pakistan, and the Philippines, and all but one from India had low values and those from the other countries were intermediate or varied.

Distinct differences in the appearance of regular milled rices from various countries were noted after cooking. Differences in appearance scores of the rices were greater among individual lots from different countries than among long-, medium-, and short-grain varieties. The long-grain kernels tended to split longitudinally and the short-grain samples to slough. Most of the regular milled rices had fuzzy edges and showed some sloughing. Parboiled milled rices increased in volume, but otherwise changed little in appearance during cooking.

Cooked kernels of parboiled milled rices were well-separated grains; most of the regular milled rice samples were slightly sticky and clumped. The most and least cohesive samples came from India. Cohesiveness or stickiness increased from long- to medium- to short-grain types of rice. Differences in cohesiveness were greater within a grain type from different countries than among grain types within a country.

Most of the cooked rice samples were fairly tender and firm--of optimum doneness. Parboiled milled rice samples were more firm and chewy than the regular milled rice samples.

Pronounced flavors, not typical of domestic rice, were evident in the rices from foreign countries. The flavors found in the cooked rices were attributed to such factors as: Storage conditions; water used in cultivation, milling, or parboiling; and fermentation during the parboiling process. The flavors were described as musty, smoky, medicinal, oily, rancid, and bitter.

4. Foreign community feeding programs. Directions for using U. S. Department of Agriculture donated commodities were developed and adapted for use in community feeding programs in Central and South American countries. Formulas and procedures were designed for 5, 50, and 100 portions, and directions were released in leaflets published by the State Department.



5. Cracked wheat bulgur. An intensive evaluation and recipe development project for cracked wheat bulgur was carried out to determine the acceptance of bulgur in various food preparations and to provide a collection of recipes that would introduce bulgur to families, institutions, and schools receiving the commodity. This was part of a U. S. Department of Agriculture program wherein cracked wheat bulgur was distributed to a selected number of States for a pilot study on the acceptance of this commodity in institutions and schools.

#### D. Oilseeds and Peanuts

1. Shortening properties of fats. Investigation of the shortening properties of five kinds of fat--corn oil margarine, hydrogenated vegetable fat, hydrogenated vegetable and animal fat, regular margarine, and butter at different levels of added fat, liquid, and sugar in white cakes is in progress. Sensory, physical and chemical measurements are being used to determine the influence of the proportion and kind of fat on the quality of the baked product. A report on levels of fats and oils in pastry and biscuits was accepted for publication in Cereal Chemistry.

2. Use of agricultural chemicals. The flavor of roasted peanuts and of peanut butter made from Virginia Jumbo Runner 56R variety grown at Holland, Virginia, was evaluated to determine the effect, if any, of growing peanuts on phorate treated soil. Peanuts were grown in control plots and in plots treated with 2 pounds active ingredient per acre phorate (O,O-diethyl-S-(ethylthio)methyl phosphorodithioate), a systemic insecticide. A report on the results is in preparation.

#### E. Meat and Meat Products

1. Quality of cooked beef. Research on the cooking quality of beef differing in amounts of fatness and connective tissue is in progress. Laboratory work has been completed on steaks from the 9- 10- 11-rib cut and the eye of round from 20 beef carcasses. Data have been collected on the quality characteristics of raw steaks and on cooked steaks after broiling to internal temperatures of 140°, 160°, or 180° F. Correlations of palatability characteristics with physical and chemical determinations of fat, moisture content, and color will be investigated and related to observable characteristics. Results will be used to guide recommendations for improved methods of cooking.

2. Quality of cooked lamb. An integrated report of research conducted at Beltsville, Maryland, and Davis, California, is in preparation as a USDA bulletin on relationships between age and fatness of animal and the physical composition, flavor, tenderness, and juiciness of cooked lamb meat. Included are data on 1,524 cuts of meat from 286 animals, 4- to 80-months old, evaluated either raw or cooked.

Results of certain aspects of the research on lamb were reported at the International Congress of Food Science and Technology in London, England.

3. Quality of pork hams, uncured and cured. Color, juiciness, and flavor characteristics of the lean meat from cooked and uncooked cured hams were evaluated as both warm and cold samples. The hams came from carcasses selected for low, medium, and high thickness of subcutaneous fat and low and high marbling levels. A manuscript is in preparation on this part of the research.

Data on the yield of separable lean, cover fat, intermuscular fat, skin and bone determined at Beltsville for 24 pairs of cooked and uncooked cured hams and similar data for 24 pairs of fresh and cured hams determined under contract at the University of Illinois are being analyzed. Manuscripts are being prepared.

4. Pork sausage storage. Studies are in progress on the use of an antioxidant combination upon maintenance of palatability of pork sausage links during refrigerator and freezer storage. Pork sausage links made with and without butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) and frozen immediately after processing are being evaluated for palatability 11 days after processing, (comparable to normal marketing period), and after refrigerator (45° F.) and freezer (0° F.) storage intervals selected as representative of household practice. This work is cooperative with the Meat Inspection Division.

5. Fresh, frozen, canned meat products. The preparation time, serving yield, food components, and quality characteristics for home-prepared and purchased chilled, frozen, and canned meat products were determined. Results have been summarized for publication as a Department bulletin along with similar data on poultry, cheese, and fish items.

Many of the commercially prepared foods took 10 minutes or less active preparation time. For home-prepared foods required active preparation time ranged from less than 1 minute for ham to 30 minutes for meat stew. Over half of the home-prepared products required more than 25 minutes active preparation time. Total preparation time ranged from 35 to 175 minutes for home-prepared products. For commercially prepared products, total preparation time required in the home ranged from 7 to 263 minutes when thawing time was included, and 7 to 161 minutes when cooking time only was included.

The lean meat content in frozen dinners or main courses ranged from 31 to 44 percent of the weight of the ready-to-eat food. The content of lean meat in frozen beef pie was 16 percent and in canned beef stew, 15 percent. The lean meat content in four brands of frozen beef pie varied from 15 to 20 percent of the weight of the ready-to-eat pie.

The majority of the commercial products, like the home-prepared products, were attractive in appearance and had good eating quality.

6. Freeze-dried products. Freeze-dried meat products were evaluated for general acceptability, appearance, flavor, juiciness, texture or consistency, and tenderness in cooperation with the Marketing Economics Division, Economic Research Service. The object was to provide information on which to base estimates of consumer acceptability of freeze-dried products in retail, institutional, and manufacturing markets, and suitability of these foods for specialized uses such as emergency rations, catering, and armed services use.

Food products included in a comparative study of freeze-dried foods and other processed forms of the same food were sliced beef and gravy, vegetable-beef stew, beef noodle soup, chili with beans, swiss steak dinner, ranch-style breakfast (sausage and eggs), diced beef, diced ham, hamburgers, beef steak, and pork chops. Either frozen or canned processed products were selected for comparison with the freeze-dried foods whenever possible. Fresh products were selected only if a processed one was not available on the local retail market.

None of the freeze-dried foods were considered unacceptable or very poor in quality. The general acceptability of freeze-dried beef noodle soup was significantly higher than that for canned soup; the quality characteristics of flavor, texture, and appearance were not significantly different. Quality characteristics of freeze-dried diced beef, beef steaks, and sliced beef and gravy usually were rated lower than for the canned or frozen counterpart. The freeze-dried products given low scores were weak or lacking in flavor or off-flavored, fibrous, stringy, powdery, mealy or woody in texture, and tough and chewy in tenderness.

No significant differences were noted between freeze-dried and frozen hamburgers. Freeze-dried pork chops and diced ham were most palatable of all freeze-dried meat products; however, they were not as good as frozen pork chops or canned ham. The general acceptability of freeze-dried combination dishes was fair to good for vegetable beef stew, chili with beans, and sausage from the ranch-style breakfast, and poor to fair for swiss steak and peas.

Results of these studies are published in a marketing research report.

#### F. Poultry and Poultry Products

1. Heating procedures and eating quality of turkey. Changes in muscle structure, fat and moisture content, tenderness, juiciness and flavor induced by different heating times, oven temperatures and degrees of doneness used in roasting and braising are being studied for boneless turkey roasts and whole turkeys.



Research is in progress on boneless turkey rolls obtained from Iowa and from Virginia, roasted at oven temperatures of 250°, 325°, and 400° F., and to internal temperatures ranging from 161-212° F.

Eating quality and heat penetration was determined for 8 Bronze tom turkeys from Virginia, and 10 Beltsville Small White tom turkeys from Maryland, when stuffed and roasted in a 325° F. oven to an endpoint temperature of 195° F. in the breast muscles. Plans are underway to obtain turkeys grown in California for comparison with those grown in Virginia and Maryland.

Research under contract with Purdue University has been initiated to study bacteriological and quality characteristics of turkeys stuffed and roasted under different conditions. Results will be used to re-evaluate cooking times for large turkeys and the criteria for determination of cooking endpoint.

2. Freezer storage of chicken. Broiler-weight chickens obtained from commercial plants were evaluated for weight loss during cooking and for palatability within 4 days after processing and after 6 months storage at 0° F. Chickens were roasted at an oven temperature of 400° F. to an endpoint temperature of 195° F. in the breast meat. There were no appreciable differences in odor, juiciness, tenderness, or flavor of breast or thigh meat between the unstored or frozen stored chickens. Addition of sodium chloride or sodium polyphosphate to the chill water during processing did not affect the above characteristics. The use of polyphosphate helped slightly in maintaining the flavor of cooked breast meat held in the refrigerator for 48 hours and then reheated. It did not affect the other palatability qualities. Cooking losses were slightly less for chickens treated with polyphosphate than for untreated or sodium chloride treated birds. The work was cooperative with the Agricultural Marketing Service and results will be used in Department publications.

3. Fresh, frozen, and canned products. Preparation time, serving yield, food components, and quality characteristics were determined for home-prepared and purchased canned, chilled, frozen chicken and turkey products.

Commercially prepared foods generally required less time for active preparation and less total preparation time than did the home-prepared counterparts as would be expected. Active preparation time for home-prepared foods ranged from 10 to 54 minutes, depending on the number of ingredients and the complexity of the preparation procedures involved. Less than 10 minutes of active preparation time was needed for preparing four servings of most of the commercial products. Commercially prepared foods were ready for serving in 2 to 47 minutes total time. Total time for home preparation of commercially prepared foods extended to 242 minutes when it included thawing time, as compared with 250 minutes for completely home-prepared foods that required long cooking.

The lean meat content in frozen poultry dinners or main courses ranged from 19 to 22 percent of the weight of the ready-to-eat food. In chilled and frozen pies, average lean meat content ranged from 12 to 17 percent, and in combination dishes, from 3 to 16 percent. In three brands of frozen chicken dinners, the average meat content ranged from 20 to 22 percent; in two brands of turkey dinners, from 19 to 26 percent; and in three brands of frozen chicken pies, from 12 to 17 percent.

The majority of the commercial products, like the home-prepared products, were attractive in appearance and had good eating quality.

Results have been summarized for publication in a Department bulletin on consumer quality characteristics, composition, yield in servings, cost, and preparation time of various market forms of these foods.

4. Freeze-dried products. The general acceptability and eating quality of the freeze-dried poultry products in relation to other processed canned or frozen forms of the same food product were evaluated by a laboratory taste panel.

Freeze-dried diced chicken generally rated lower than canned chicken on all quality characteristics of flavor, texture, tenderness, juiciness and appearance, and on general acceptability. When the chicken was served in salad or in creamed chicken, general acceptability was better than when it was served plain-cooked. The freeze-dried chicken was described as off-flavored, tough, fibrous, woody, and mealy by the panel.

Freeze-dried chicken stew received palatability scores significantly lower than the canned product, except for appearance and juiciness. Scores for the freeze-dried chicken rice dinner were significantly lower, except for appearance, than for the laboratory-prepared chicken rice dinner.

Scores for freeze-dried chicken rice soup and chicken noodle soup were usually similar to or higher than those for the corresponding canned soup. The flavor of freeze-dried scrambled eggs cooked in sausage drippings was rated fair, but lower than flavor scores for scrambled fresh eggs. The scores for other quality characteristics of freeze-dried scrambled eggs were similar to scores for scrambled fresh eggs. Apparently, some quality characteristics of freeze-dried poultry products need improvement before they can compete with frozen or canned poultry products. The results of this research have been published in a Marketing Research Report.

G. Food Buying Guides

1. For school lunch managers. A revision of PA-270, Food Buying Guide for Type A School Lunches, was completed in cooperation with the Agricultural Marketing Service. New data were added to the 1955 edition and the format was changed to make the guide more useable by school lunch managers participating in the National School Lunch Program.

2. For families. Work has been initiated on a food buying guide for family use.

PUBLICATIONS

Fruits and Vegetables

1963. Making pickles and relishes at home. CA 61-14 Revised, USDA, ARS, HN, 16, Processed.

Grain Products

Matthews, R. H., and Batchner, O. M. 1963. Sifted vs. unsifted flour: weight variations and results of some baking tests. Jour. Home Econ., 55, (2), pp. 123-124.

Murphy, E. W., Marsh, A. C., and Dawson, E. H. 1963.

Baked products--consumer quality, composition, yield, and preparation time of various market forms. Home Econ. Res. Rpt. No. 22, 39 pages.

1963. How to make pastry with less fat in an electric mixer. CA 61-16, USDA, ARS, HN, 3 pages.

1963. Whole-wheat (graham) flour recipes. CA 61-15 Revised, USDA, ARS, HN.

1963. Bread and rolls. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 14 pages.

1963. Corn and cornmeal. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 10 pages.

1963. Wheat and wheat products. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 10 pages.

1963. Bulgur or trigor. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 7 pages.

1963. Rice and beans. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 9 pages.

1962. Bulgur. Food Distribution Division, Agricultural Marketing Service. Human Nutrition Research Division cooperating. 1 page.

1962. Bulgur in family meals. Food Distribution Division, Agricultural Marketing Service. Human Nutrition Research Division cooperating. 2 pages.

Dairy Products

1963. Nonfat dry milk and cheese. Agency for International Development, Department of State. Human Nutrition Research Division cooperating. 12 pages.

Meat and Meat Products

- Breidenstein, B. B., Breidenstein, B. C., and Corrigan, D. S. 1962. Interrelationships of fat deposits in pork hams. Abstract. Jour. Animal Science, 21, (4), pp. 978-979.
- Paul, P. C., Torton, J., and Spurlock, G. M. 1962. Effect of pre-slaughter nutrition on palatability and composition of lamb. Abstracts of Papers. First International Congress of Food Science and Technology, London. pp. 44-45.

Poultry Products

- Beloian, A., and Schlosser, G. 1963. Adequacy of cooking procedures for destruction of Salmonellae. Amer. Jour. of Public Health, 53, pp. 782-791.

General

- Bird, K. 1963. Palatability tests of freeze-dried foods. Marketing Research Report No. 617, 36 pages, illus. Human Nutrition Research Division cooperating.
- Harp, H., and Dunham, D. 1963. Comparative costs to consumers of convenience foods and home-prepared foods. Marketing Research Report No. 609, 91 pages, illus. Human Nutrition Research Division cooperating.



Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
HN 1	Nutrients and related substances in foods.			
HN 1-5C (Rev.)	Vitamin B <sub>6</sub> values in foods.	Beltsville, Md.	Yes	3-A-1,3
HN 1-7 (Rev.)	Proximate composition of foods as purchased and as served.	Beltsville, Md.	Yes	3-A-1 3-C-1,2,3 3-F
HN 1-13C (Rev.)	Analysis of foods for fatty acid composition.	Beltsville, Md.	Yes	3-D-1,2
HN 1-15	Mineral elements in foods.	Knoxville, Tenn.		
HN 1-17	Microbiological assay methods for B-vitamins in foods.**	Beltsville, Md.	Yes	3-B-1,2,3
HN 1-18	Net synthesis or reduction of selected B-vitamins by microorganisms.**	Beltsville, Md.	No	
HN 1-19	Chemical determination of B-vitamins in foods.	Beltsville, Md.	No.	
HN 2	Functions of nutrients and their metabolic interrelationships.	Beltsville, Md.	Yes	3-A-3
HN 2-1	Diet in relation to premature physical impairment.**	Beltsville, Md.	Yes	
HN 2-15	Analysis of records of a rat colony and development of animals for specific experimental purposes.	Beltsville, Md.	Yes	1-A-1,6
HN 2-20	Influence of kind of dietary fat on growth, longevity, and histological changes in tissues of the rat.	Beltsville, Md.	Yes	1-A-3
HN 2-21	Influence of kind of dietary fat on the chemistry of the tissues of the rat at different stages of their life cycle.	Beltsville, Md.	Yes	1-A-5,6 1-A-2,5 B-1, C
HN 2-24	The effect on rat carcass composition of varying proportions of dietary proteins and carbohydrates.	Beltsville, Md.	Yes	
HN 2-35	Effect of graded levels of dietary thiamine prior to and during pregnancy on reproduction in the rat.**	Beltsville, Md.	No	
HN P-1	Pioneering Laboratory for Cellular Metabolism.	Beltsville, Md.	Yes	1-D-1
HN 3	Food quality, preparation, and preservation.	Beltsville, Md.	Yes	1-B-3, 4-D-2
HN 3-8	Palatability of selected foods and food products exposed to agricultural chemicals in their production, processing or handling.	Beltsville, Md.	Yes	4-B-2,D-2 E-4-6,F-4
HN 3-9	Development of methods for evaluating the cooking quality of rice.**	Beltsville, Md.	Yes	4-C-3
HN 3-13C	Palatability of cooked lamb as related to physical and chemical properties and to production and marketing practices.**	Beltsville, Md.	Yes	4-E-2
HN 3-14C	Cooking quality, palatability and yield of cooked pork as related to physical and chemical properties of cuts and of carcasses.**	Davis, Calif. Beltsville, Md. Ames, Iowa Urbana, Ill.	Yes	3-A-2,B-2 C-2,4-E-3
HN 3-16	Quality and yield of selected foods in different market forms.**	Beltsville, Md.	Yes	4-E-5,F-3
HN 3-17	Exploratory study of variation in cooking quality of beef from the retail market.	Beltsville, Md.	Yes	4-E-1
HN 3-18	The range in proportions of basic commodities feasible for preparation of good quality baked products.	Beltsville, Md.	Yes	4-C-1,2 D-1
HN 3-19	Physical, chemical, and eating quality characteristics of fruits in relation to household practices.	Beltsville, Md.	Yes	4-A-1,2
HN 3-20	Processing requirements and quality of homemade pickles and relishes.**	Beltsville, Md.	Yes	4-A-2,B-1
HN 3-21C	Preparation factors influencing the quality characteristics of cooked poultry meat.	Beltsville, Md. Lafayette, Ind.	Yes	4-F-1,2
SL-AMS 1/	Technical assistance on food and nutrition problems in the National School Lunch Program.	Beltsville, Md.	Yes	4-A-3, C-4,5,G-1
HN 5	Biological evaluation of foods and diets.			
HN 5-1	Comparative availability of amino acids in foods as determined with microorganisms.	Beltsville, Md.	Yes	3-E-1

Line Project Check List -- Reporting Year July 1, 1962 to June 30, 1963 (Contd.)

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area & Sub-Subheading
HN 5-2C	Metabolic response of human adults to different combinations of dietary protein and fat.	Los Angeles, Calif.		
		Lincoln, Nebr.	Yes	2-A-1
HN 5-3C	Lipid metabolism during growth as affected by kind and amount of dietary fat and carbohydrates.	Oakland, Calif.	Yes	1-A-5
HN 5-4C	Nutritional response of rats to diets containing selected types of heat-treated and rancidified fats.	Beltsville, Md.		
		Chicago, Ill.		
		New York, N. Y.	Yes	1-A-4
HN 5-5C	Utilization of dietary protein as affected by <u>in vivo</u> breakdown of urea.	Chicago, Ill.	Yes	1-B-2
HN 5-6	Nutritional value of various components of milk when fed singly and in combination to rats.	Beltsville, Md.	Yes	3-D-3
HN 5-7	Further analyses of data from coordinated studies of the metabolic response of young men and women to selected patterns of essential amino acids.*	Beltsville, Md.	Yes	2-B-3
HN 5-8	Lipid biosynthesis as a criterion for assessing the biological value of foods.*	Beltsville, Md.	Yes	3-D-4
HN 6	Human nutritional requirements.			
HN 6-1C	Metabolic response of human adults to controlled diets containing different types and amounts of fat.**	University, Ala.		
		Fayetteville, Ark.		
		Pullman, Wash.	Yes	2-A-2
HN 6-2C	Metabolic response of human adults to controlled diets containing different types of carbohydrate and fat.**	Fayetteville, Ark.	Yes	2-A-2
HN 6-3	Development of basic nutrition data on calcium and magnesium metabolism (for research workers).	Beltsville, Md.	No	
HN 6-4	Comparative analyses of the height-weight relationship for people in different countries.	Beltsville, Md.	Yes	2-C
HN 6-5	Preparation for publication of basic nutrition and metabolic data on normal preadolescent girls.	Beltsville, Md.	Yes	2-B-2
HN 6-6	Human metabolic response to mono-type diets.	Beltsville, Md.	Yes	2-A-1
HN 6-7	Metabolic patterns of preadolescent girls maintained on controlled diets.*	Beltsville, Md.	Yes	2-B-2
HN 6-8C	Metabolic response of normal adolescent boys and girls to a standardized diet to give information on nutritional requirements.*	Beltsville, Md.		
		Berrien Springs, Mich.	Yes	2-B-1
HN 6-9	Human metabolic response to rate of food intake.*	Beltsville, Md.	Yes	2-A-3

1/ Supported in part by funds from Agricultural Marketing Service.

2/ In cooperation with Southern Regional Project S-28, Revised.

\* Initiated during reporting year.

\*\* Discontinued during reporting year.

\* Initiated during reporting year.

\* Initiated during reporting year.









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A summary of current program ... and preliminary report of progress: Human NL  
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